INTENSE ANNUAL GENERAL MEETING AT PISA

Muography of Vesuvius

Giovanni Macedonio

on behalf of the MURAVES Team, Italy

Pisa, 6-7 November 2019

The Muography Team

Involved in the MURAVES experiment on Vesuvius

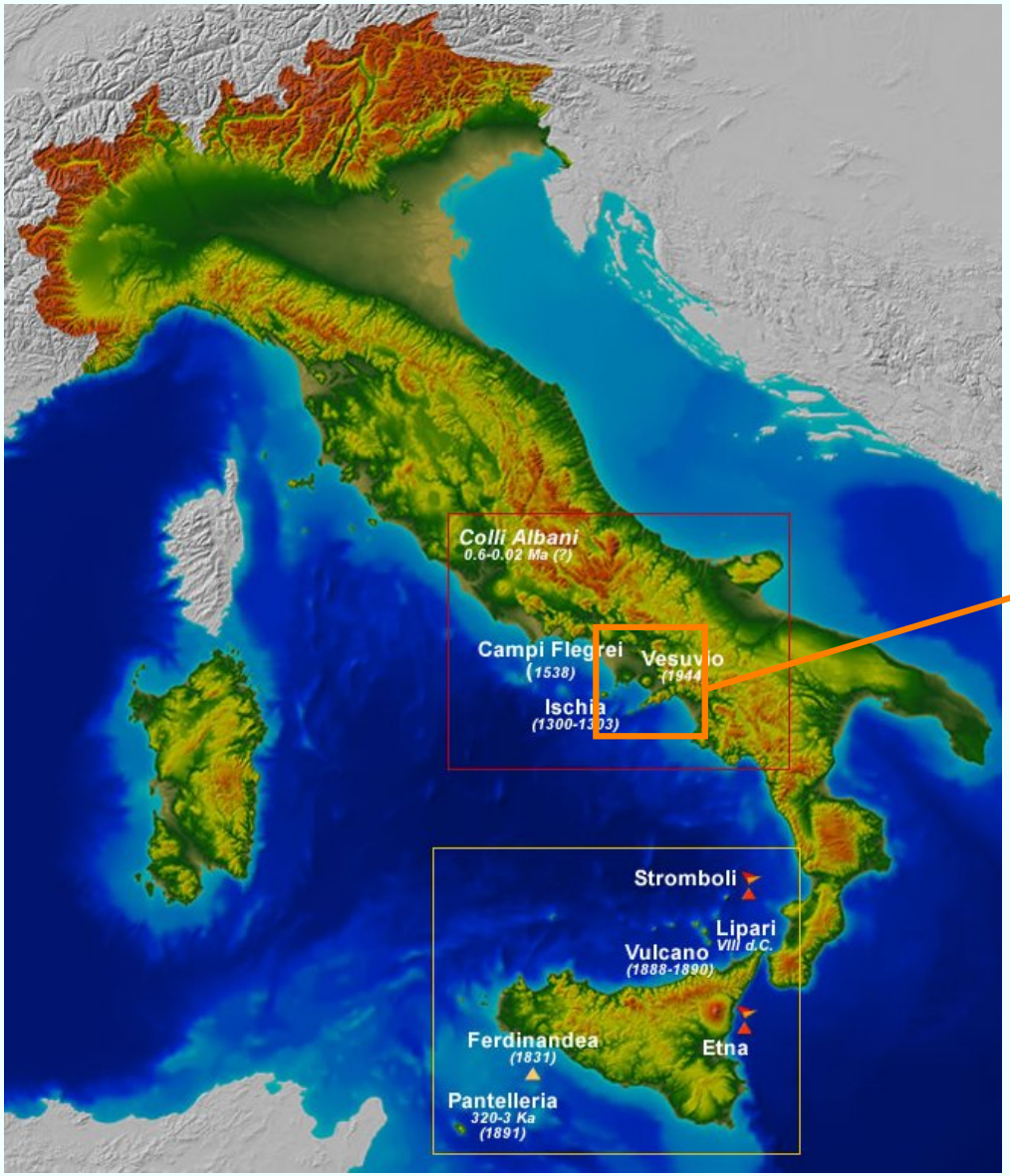
People

Ambrosino F.[1,2], Baccani G.[3,4], Bonechi L.[3], Bongi M.[3,4], Bross A.[5], Ciaranfi R.[3], Cimmino L.[1], Ciulli V.[3,4], D'Alessandro R.[3,4], D'Errico M.[1], Giudicepietro F.[6], Gonzi S.[3,4], Macedonio G.[6], Martini M.[6], Masone V.[1], Melon B.[3,7], Noli B.[1], Orazi M.[6], Passeggio G.[1], Peluso R.[6], Pla-Dalmau A.[6], Roscilli L.[1], Saracino G.[1,2], Scognamiglio L.[1], Strolin P.E.[1,2], Tanaka H.K.M.[8], Vertechi E.[6]

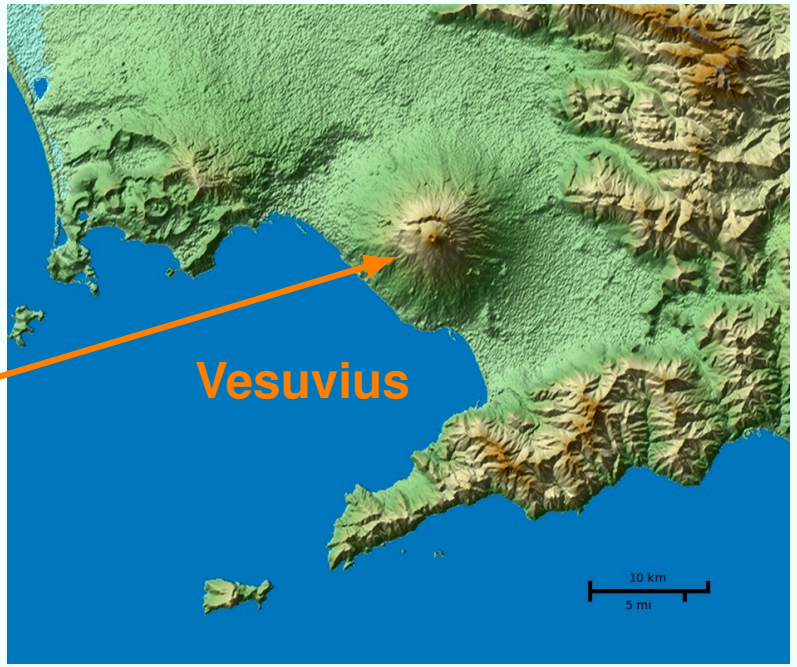
Institutes

[1] Istituto Nazionale di Fisica Nucleare (INFN), Sezione di Napoli, Naples, Italy
[2] Università di Napoli "Federico II", Dipartimento di Fisica, Naples, Italy
[3] Istituto Nazionale di Fisica Nucleare (INFN), Sezione di Firenze, Sesto Fiorentino, Florence, Italy
[4] Università di Firenze, Dipartimento di Fisica e Astronomia, Sesto Fiorentino, Florence, Italy
[5] Fermilab, Batavia, Illinois, USA
[6] Istituto Nazionale di Geofisica e Vulcanologia (INGV), Osservatorio Vesuviano, Naples, Italy
[7] Centro Siciliano di Fisica Nucleare e Struttura della Materia, Catania, Italy
[8] Earthquake Research Institute, The University of Tokyo

The structure of Vesuvius



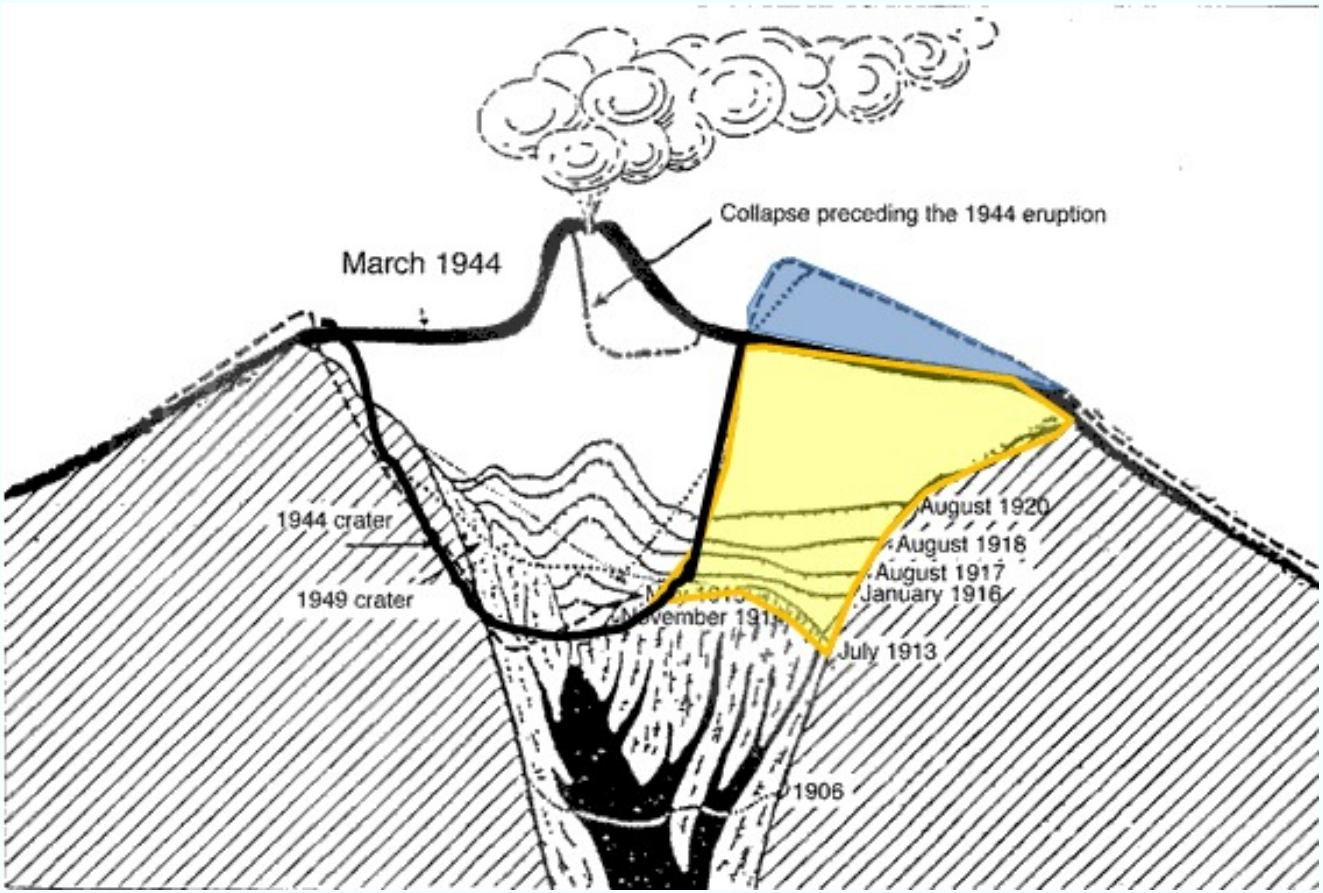
Vesuvius is an active volcano



- **Last eruption occurred in 1944**
- **Now the conduit is closed**
- **Monitored 24/7 by INGV**

Observations of the upper part of Vesuvius

The Vesuvius crater between 1906 and 1944



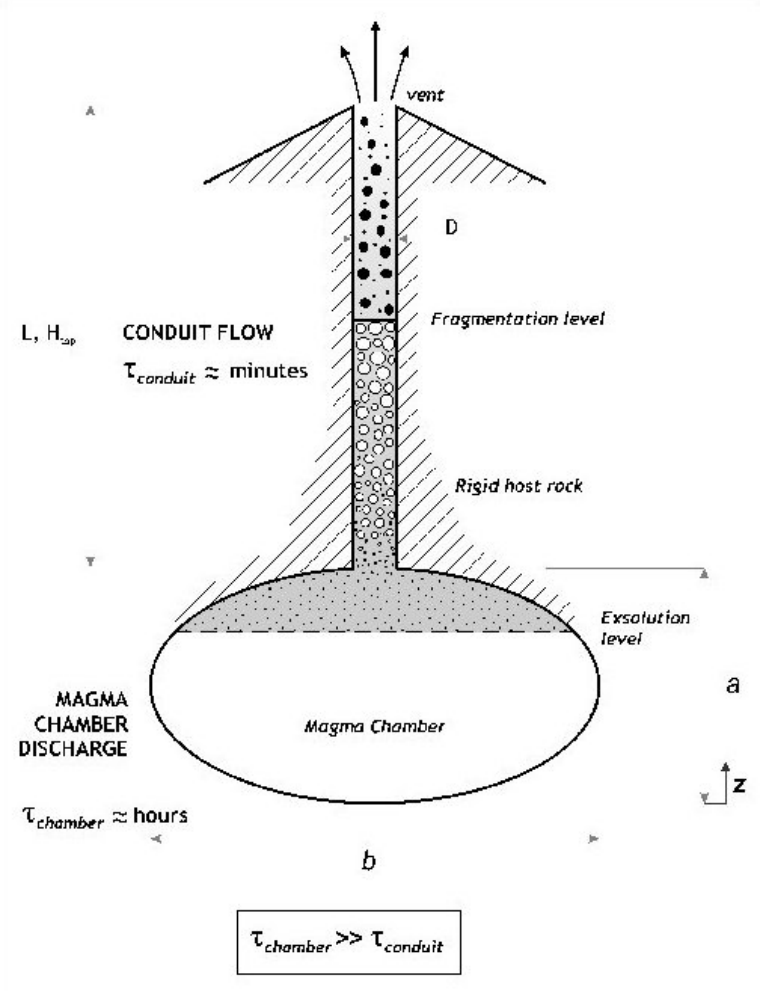
(from Imbò, 1949)

Vesuvius crater in 1944

Vesuvius crater today

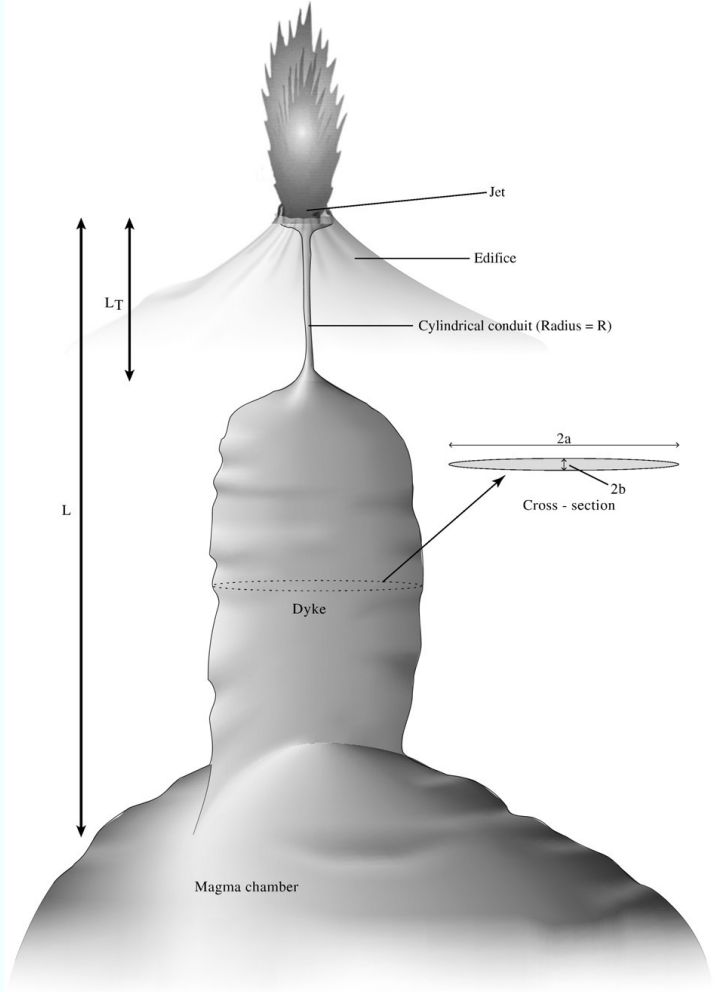
Magma chamber-conduit model

Cylindrical conduit



(Macedonio et al., 2005)

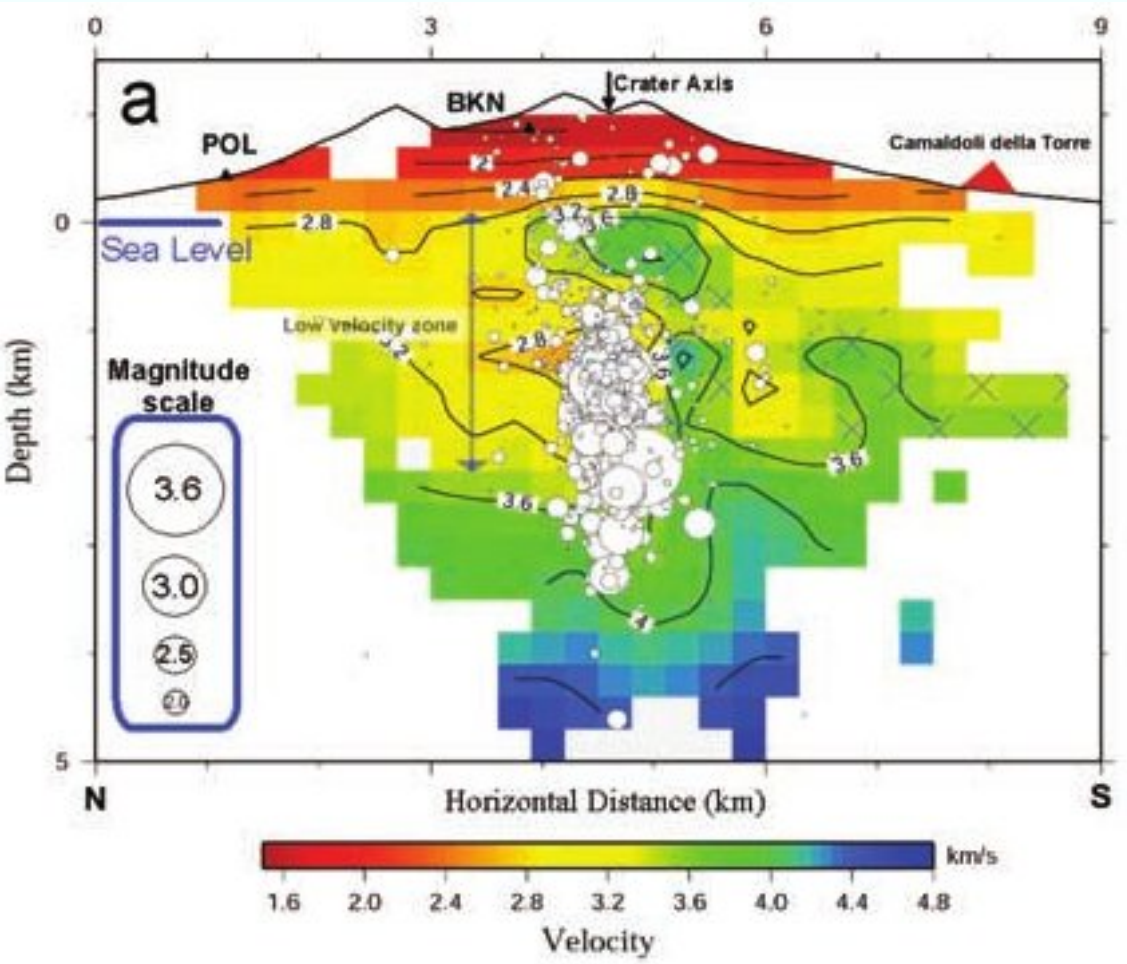
More realistic: dyke+cylinder



(Costa et al., 2009)

The internal structure of Vesuvius

High resolution **passive** seismic tomography (300-500 m)



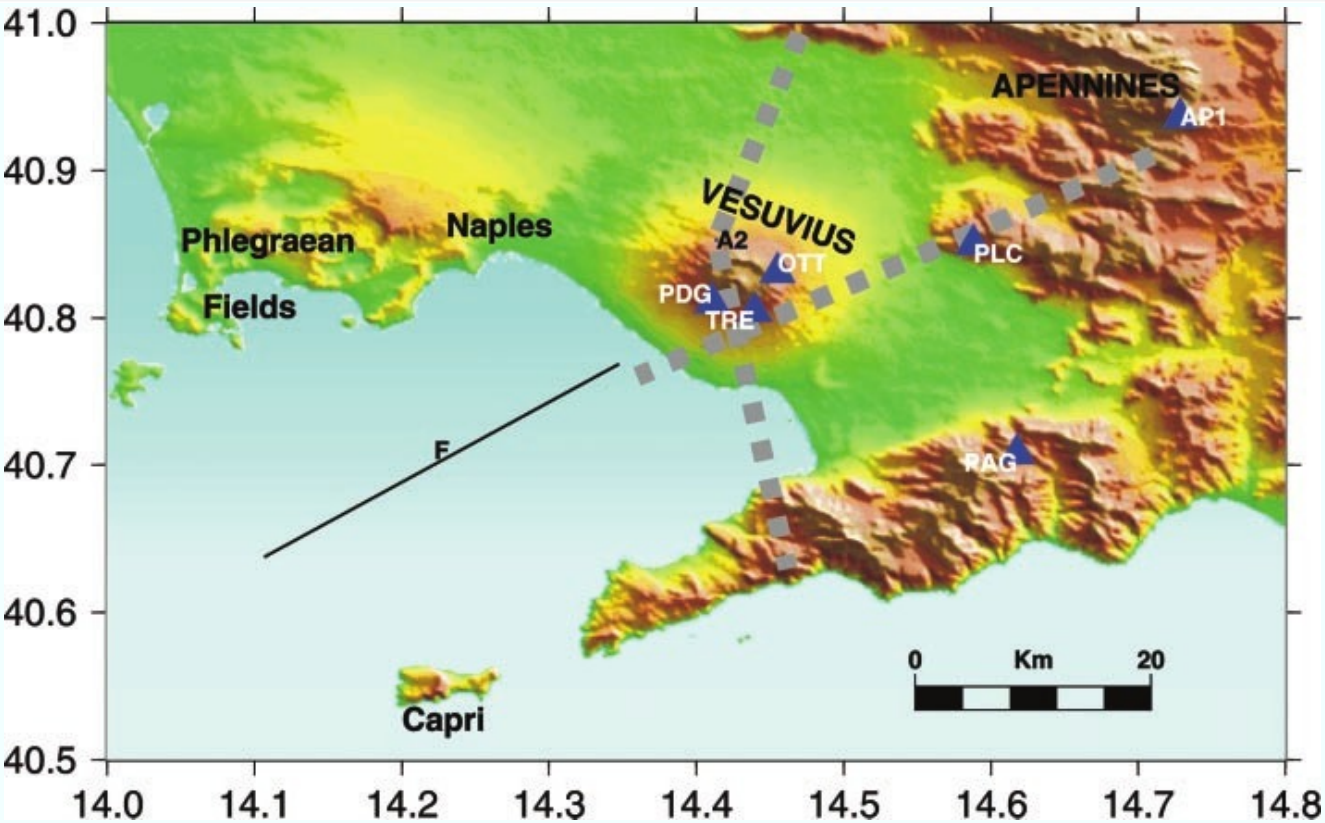
(modified after Scarpa et al., 2002)

P-wave velocity structure

- Based on simultaneous inversion of the 3-D velocity structure and the earthquake location
- Data from 2139 earthquakes recorded from minimum 7, up to 19 stations (8600 P-waves, 1900 S-wave readings)
- Magmatic bodies inside the investigated volume were not found

Active seismic tomography of Vesuvius

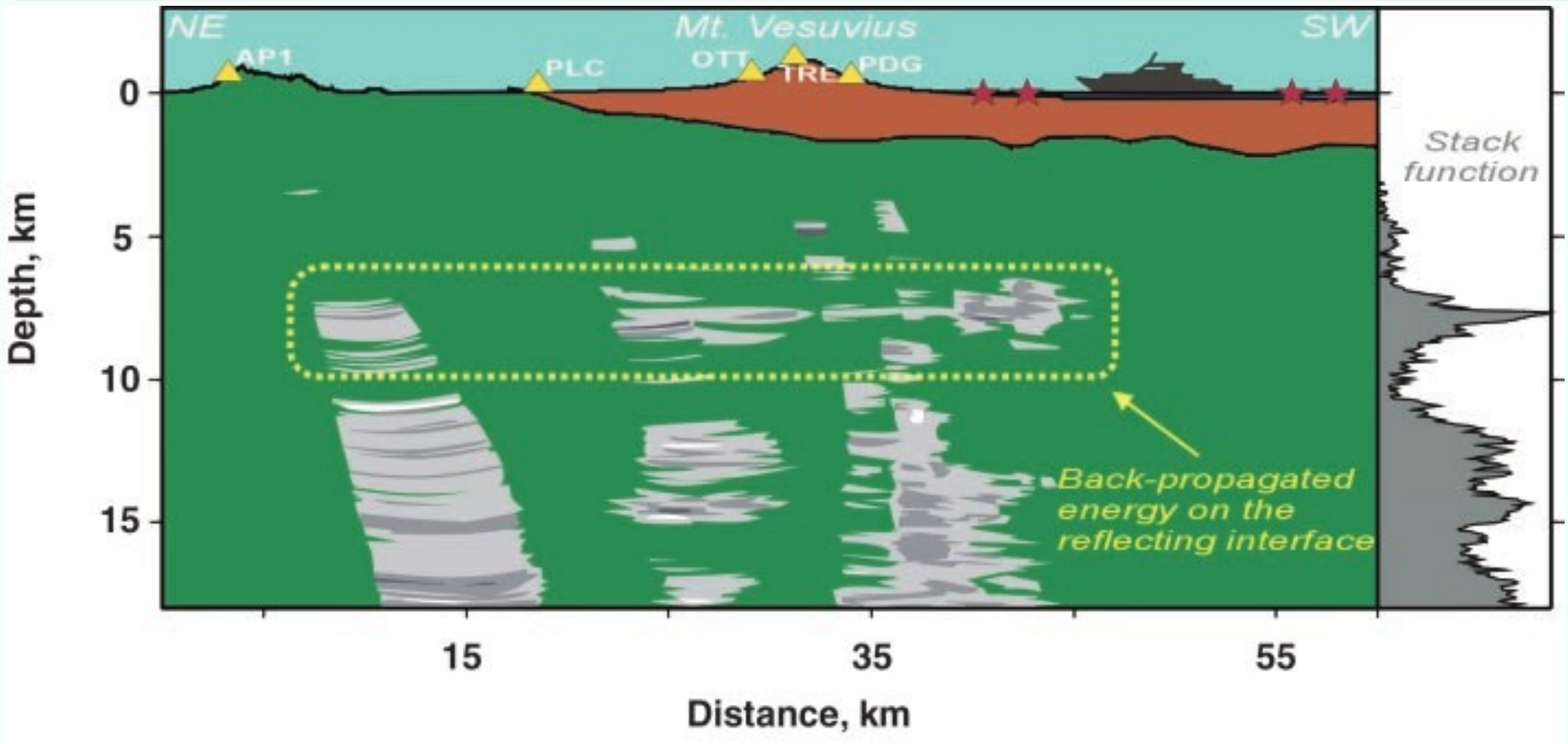
- Previous experiments Tomoves-1994, Tomoves-1996
- Mareves-1997: 1800 shots off-shore (along line F)
- 25 temporary seismic stations + permanent stations of the Osservatorio Vesuviano network



(from Auger et al., 2001)

The MAREVES-1997 active tomography experiment

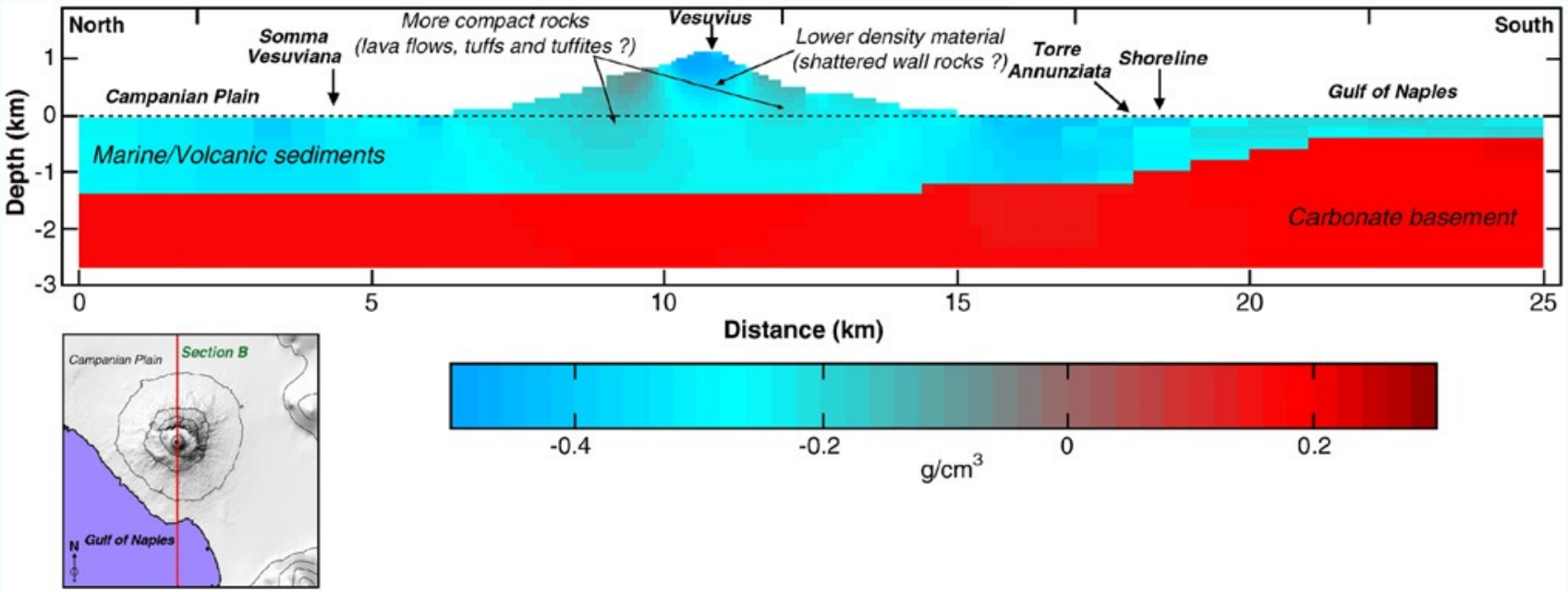
- Found the top of a magmatic body at 8 km depth, at least 400 km^2
- Thickness of the magmatic body not constrained
- $\approx$ 500-1000 m spatial resolution



(from Auger et al., 2001)

Gravimetric field inversion

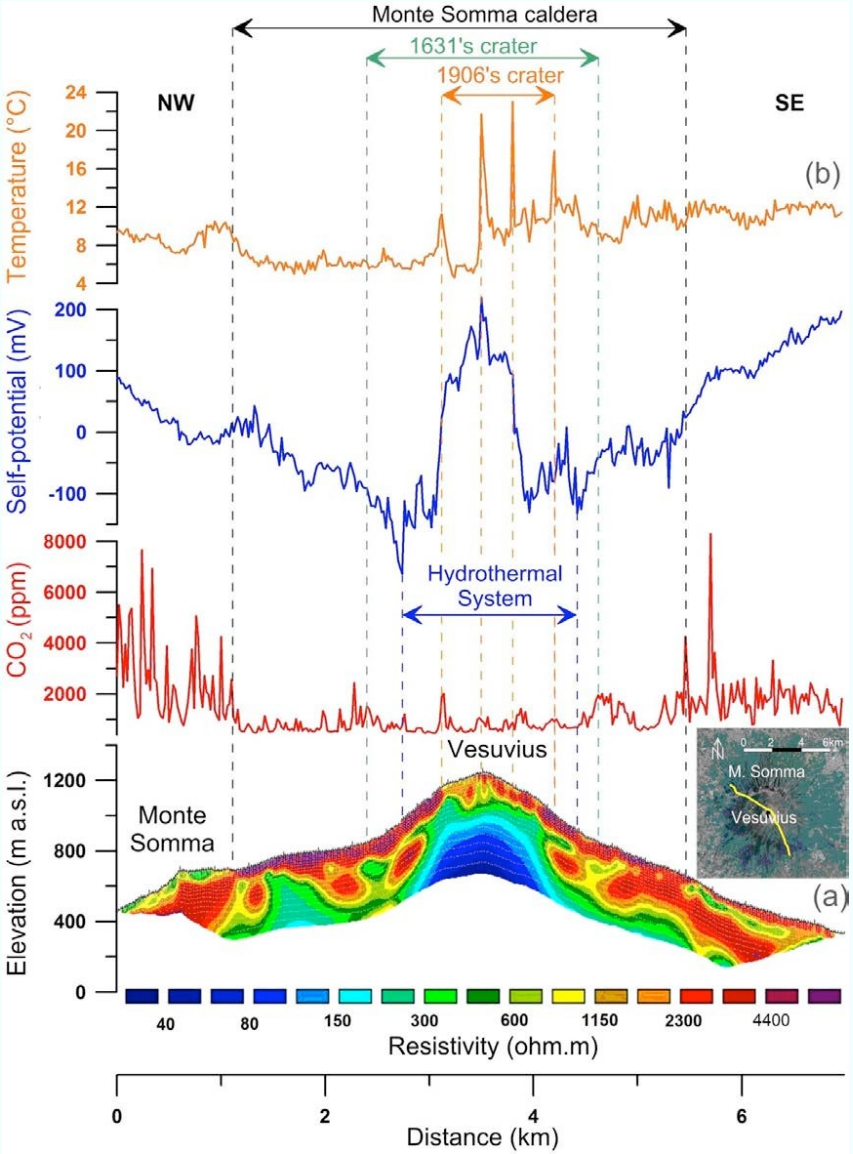
- About 300 m spatial resolution
- Model misfit $\approx$ 5%



(from Cella et al., JVGR, 2007)

The internal structure of Vesuvius

Electric resistivity

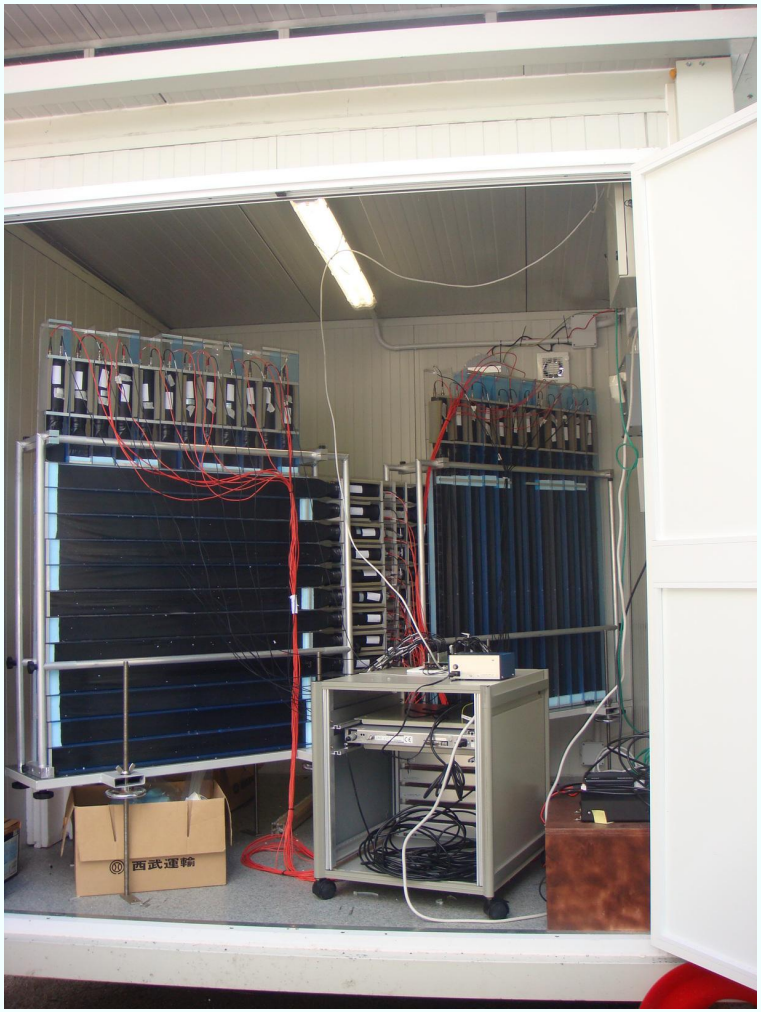


- Total profile length 7 km
- Spacing between electrodes 40 cm
- Reach 500 m depth

(Finizola et al., 2014)

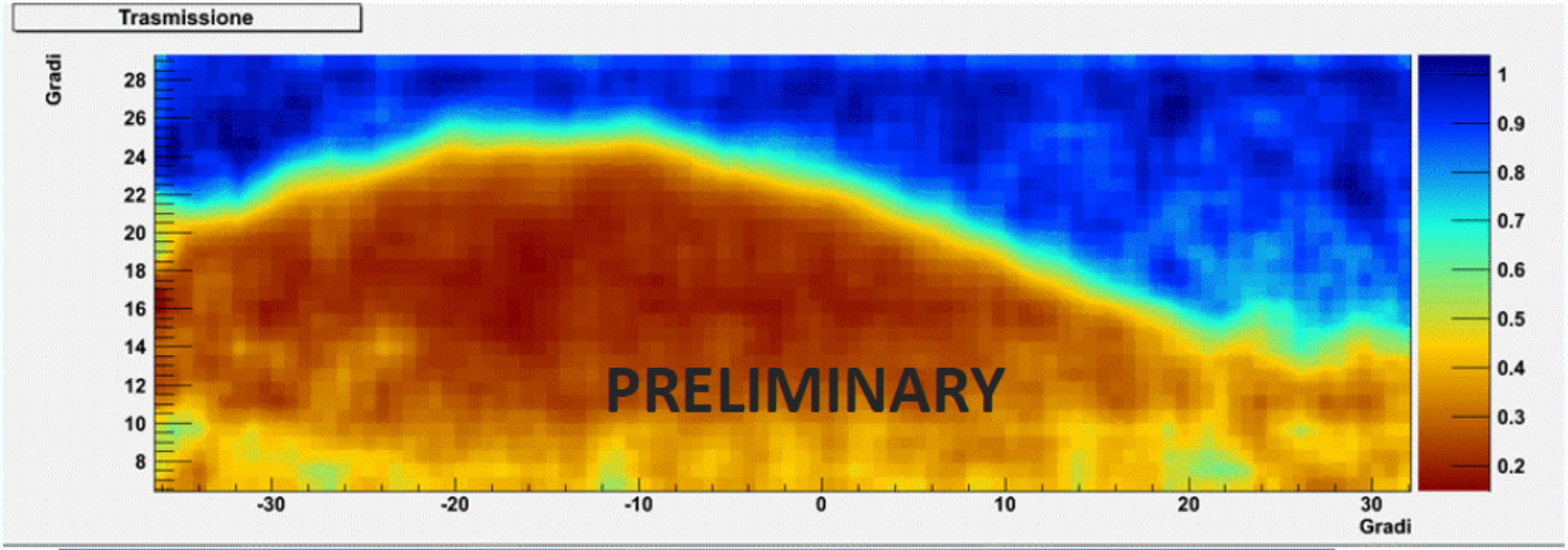
First muography experiment at Vesuvius (2009-2010)

Mounting the Japanese detector



The MU-RAY prototype (2013)

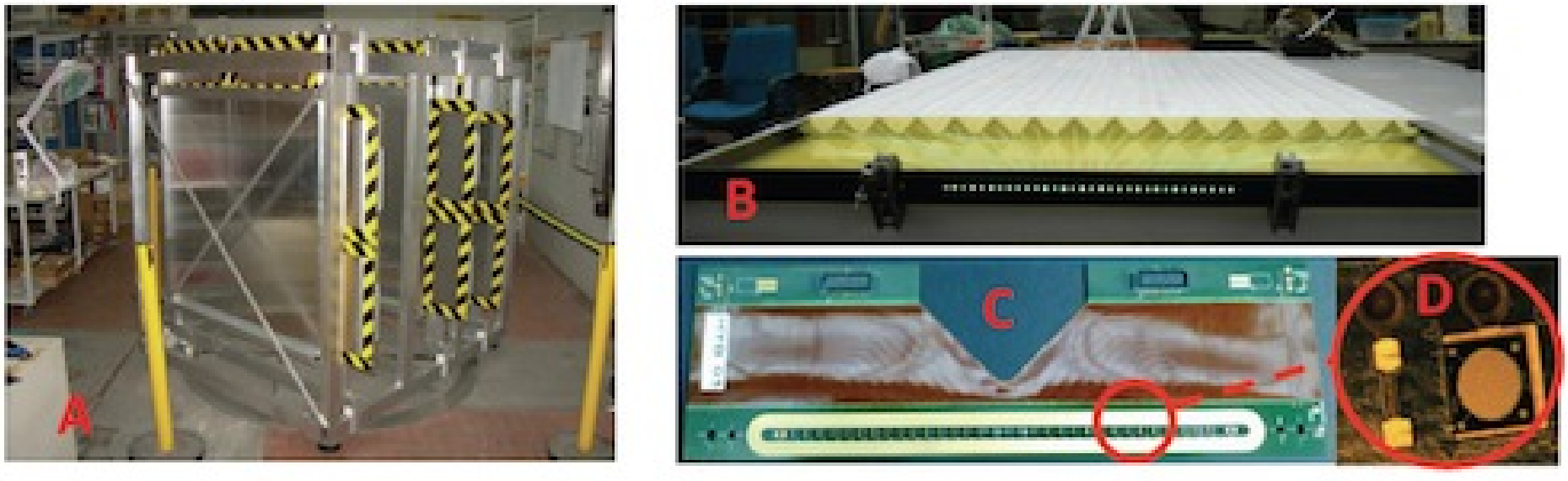
MU-RAY First results (April 2013)



The MURAVES telescope

INFN, INGV, Universities of Napoli and Florence

- Higher resolution, better background suppression
- The detector is based on **plastic scintillators** / SiPM
- Based on the **MU-RAY** technology
- At Vesuvius adopts **lead walls** for background suppression



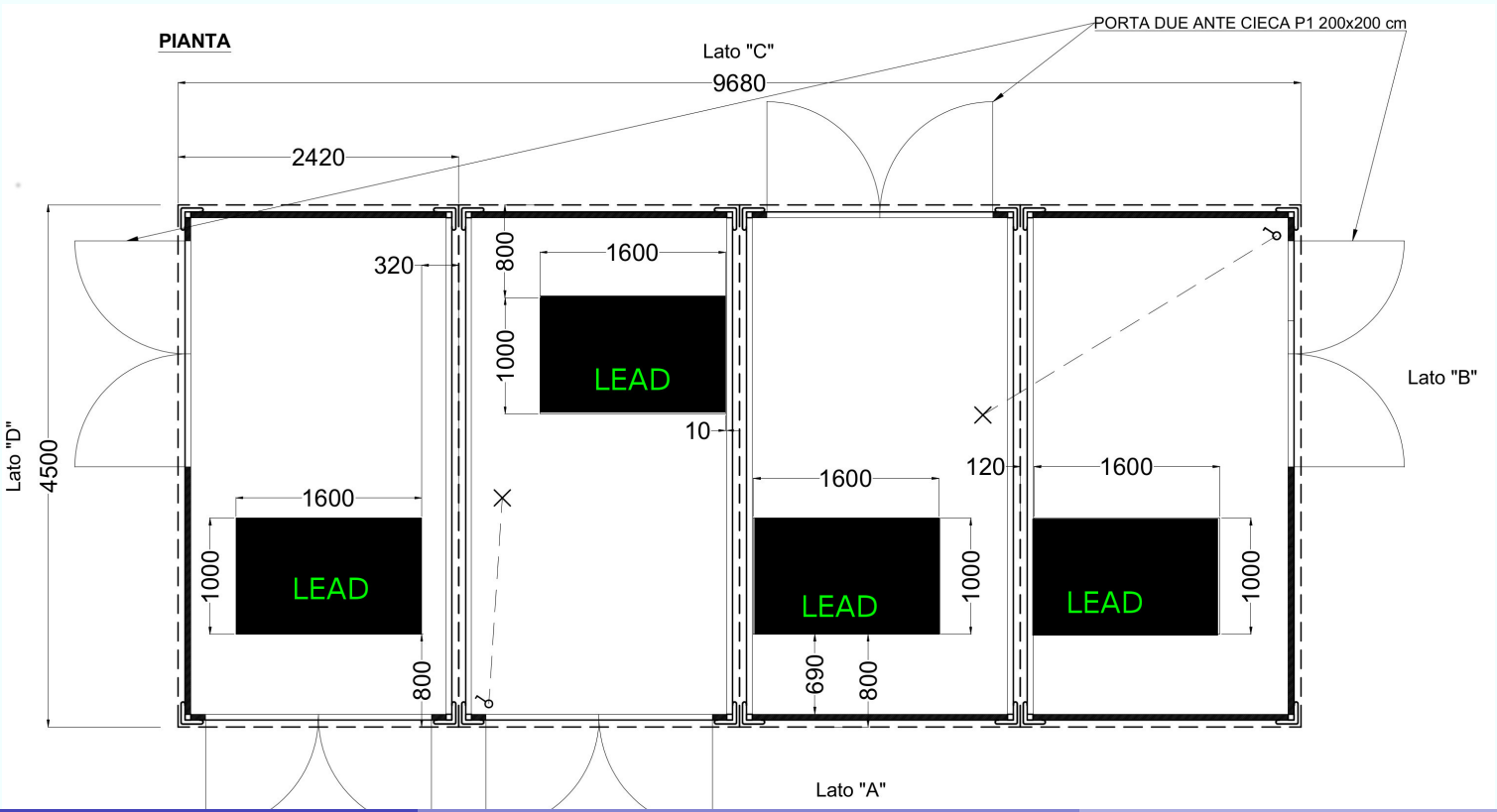
Selected site for the MURAVES detector

Inside the Vesuvius National Park

Position: E 14° 24’ 41.76”; N 40° 48’ 36.75” (675 m a.s.l.)

The Laboratory on Vesuvius

- Four aligned container modules
- Total internal: L=9.3 m, W=4.2 m, H=2.7 m
- Five doors
- Concrete basement (pre-built)
- Can host 3 detectors + 1 calibration



Container assembly

Lead from the OPERA experiment

Re-melt in bricks (Total: 35 tons)

Power supply and data transmission

- Scintillators mounted in January-February 2019
- Acquisition tests already started for detector n.1
- Three years data acquisition

Solar panels mounted on the roof

Solar panels

- 18 x 300 W solar panels
- Total power: 5400 W (peak)
- 32 lead batteries, Tot= 15.7 kWh
- Output voltage: 48 V

Internet connection

- WiFi radio-bridge

Conclusions

MURAVES Project

- MURAVES project started in 2015 (INGV + INFN)
- Collaboration with UC-Louvain (Belgium) in progress
- End of laboratory setup on Vesuvius: January 2019
- Start of data acquisition (preliminary tests): February 2019
- Current status (November 2019): data acquisition

Bibliography

Auger, E., Gasparini, P., Virieux, J., and Zollo, A.: Seismic evidence of an extended magmatic sill under Mt. Vesuvius, Science, 294, 1510–1512, 2001.

Calvari, S., Bonaccorso, A., Madonia, P., Neri, M., Liuzzo, M., Salerno, G. G., Behncke, B., Caltabiano, T., Cristaldi, A., Giuffrida, G., La Spina, A., Marotta, E., Ricci, T., and Spampinato, L.: Major eruptive style changes induced by structural modifications of a shallow conduit system: the 2007-2012 Stromboli case, Bull. Volcanol., 76, 841, doi:10.1007/s00445-014-0841-7, 2014.

Chouet, B., Dawson, P., Ohminato, T., Martini, M., Saccorotti, G., Giudicepietro, F., De Luca, G., Milana, G., and Scarpa, R.: Source mechanisms of explosions at Stromboli Volcano, Italy, determined from moment-tensor inversion of very-long period data, J. Geophys. Res., 108, doi:10.1029/2002JB001919, 2003.

Costa, A., Sparks, R. S. J., Macedonio, G., and Melnik, O.: Effects of wall-rock elasticity on magma flow in dykes during explosive eruptions, Earth Planet. Sci. Lett., 288, 455–462, doi:10.1016/j.epsl.2009.10.006, 2009.

Finizola, A., Ricci, T., Poret, M., Delcher, E., Peltier, A., Antoine, R., Bernard, J., Boudoire, G., Brothelande, E., Fanizza, G., Fargier, Y., Gailler, L., Gueguen, E., Gusset, R., Matera, A., Mezon, C., Piscitelli, S., Portal, A., Rizzo, E., Rossi, M., Calamita, G., Bellucci Sessa, E., and Nave, R.: Fluid circulation at Somma-Vesuvius volcanic complex inferred by electrical resistivity tomography, self-potential, temperature and soil degassing, in: MED-SUV 1^{th} year meeting, Nicolosi (catania) 7-9 July 2014, Miscellanea INGV no. 23, pp. 52–53, INGV, 2014.

Macedonio, G., Neri, A., Martí, J., and Folch, A.: Temporal evolution of flow conditions in sustained magmatic explosive eruptions, J. Volcanol. Geotherm. Res., 143, 153–172, doi:10.1016/j.jvolgeores.2004.09.015, 2005.

Scarpa, R., Tronca, F., Bianco, F., and Del Pezzo, E.: High resolution velocity structure beneath Mt. Vesuvius from seismic array data, Geophys. Res. Lett., 29, 2040–2043, doi:10.1029/2002GL015576, 2002.

Tanaka, H. K. M., Nakano, T., Takahashi, S., Yoshida, J., Takeo, M., Oikawa, J., Ohminato, T., Aoki, Y., Koyama, E., Tsuji, H., and Niwa, K.: High resolution imaging in the inhomogeneous crust with cosmic-ray muon radiography: The density structure below the volcanic crater floor of Mt. Asama, Japan, Earth Planet. Sci. Lett., 263, 104–113, 2007.